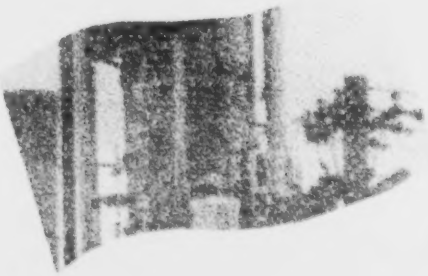
Guide for the Adjustment of Permissible Exposure Values (PEVs) for Unusual Work Schedules

2nd edition revised and updated



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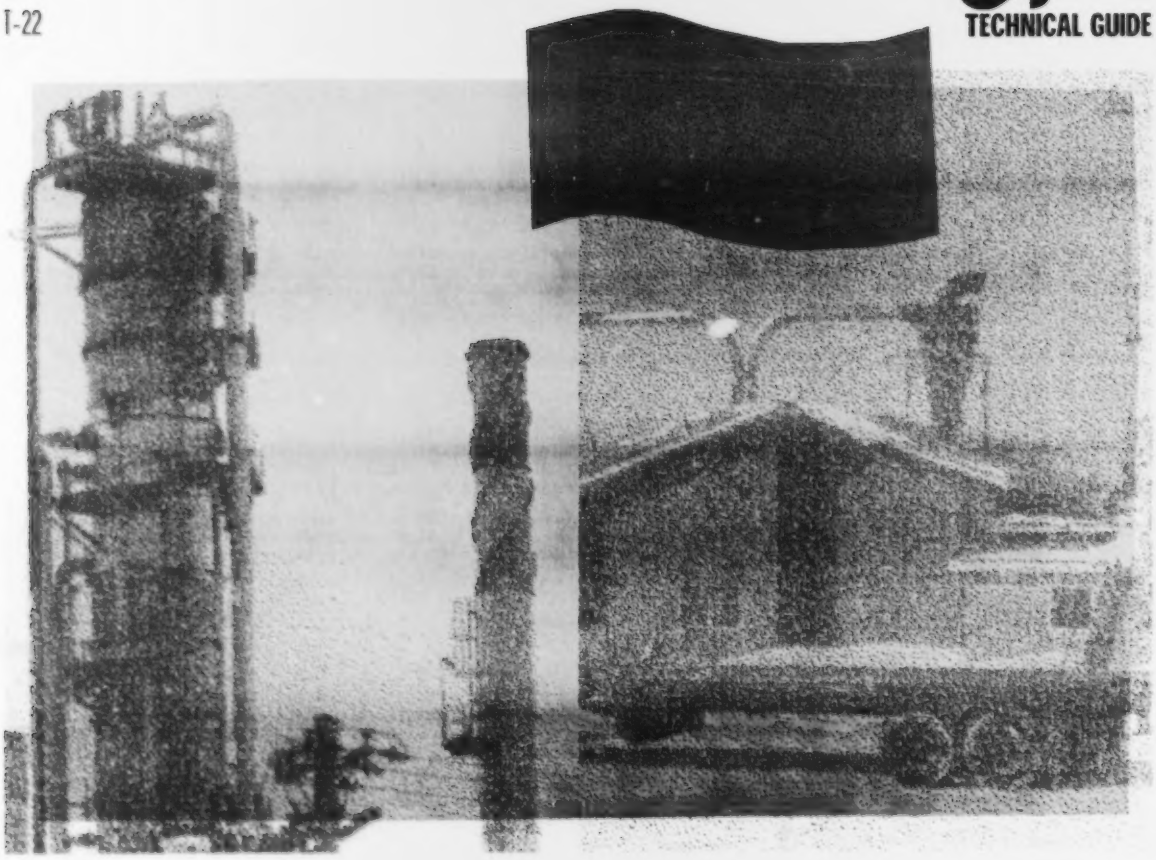

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Guide for the Adjustment of Permissible Exposure Values (PEVs) for Unusual Work Schedules

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Operations Division, IRSST

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IN CONFORMITY WITH THE IRSST'S POLICIES

The results of the research work published in this document have been peer-reviewed

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New information in this version

This second version of the *Guide for the adjustment of permissible exposure values (PEVs) for unusual work schedules* contains some changes that have taken place since the previous version. These changes are necessary to continue to comply with the content of Schedule I of the Regulation respecting occupational health and safety[1] (RROHS). Schedule I of the RROHS now contains in the *Definitions and notes* section a provision on the principle of the adjustment of PEVs with a reference to the present guide. The new substances in Schedule I were thus evaluated to assign them an adjustment category. As well, substances whose PEV or notation(s) have been modified have also been reevaluated for the same purpose. Appendix IV of this guide integrates all of these changes.

Furthermore, a computer utility available on the IRSST's Web site (put online in August 2001 at the time of the publication of the RROHS) integrates these modifications and makes it easy for users to apply the PEV adjustment principle to any of the substances in the RROHS. An overview of this utility is illustrated in Appendix III of this guide.

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Preamble

There is no doubt that standards, and the TLV® (Threshold Limit Values)[2] of the American Conference of Governmental Industrial Hygienists (ACGIH) in particular, have contributed greatly to the prevention of occupational diseases caused by worker exposure to hazardous substances. However, the scope and limitations of the TLVs® must be clearly understood to discuss their adjustments. Note that TLVs® assume an applicability to almost all workers with a regular work schedule of 8 hours per day, five days per week. The ACGIH notes that the adjustment of TLVs® in the case of extended work schedules requires a "particular judgment " and has recommended, in the last few years, the use of the "Brief and Scala" correction model.

Our efforts to support the judgment of hygienists and to promote a uniform application to all Québec workers have led to an expertise-related process and a review of the entire permissible exposure value (PEV) adjustment file. This subject is constantly evolving. The present guide aims to advance the field while allowing exchanges with our partners and adaptation to field observations.

This guide is the fruit of scientific expertise, consultations and bipartite consensus. It proposes a structured process that continues to be complex despite all the efforts that have been made and continue to be made to simplify it without increasing worker health risks. But this complexity reflects the significance and method of PEV application that serve as reference conditions.

PEV adjustment is based on the toxicological knowledge available in the scientific and technical literature. However, the limits of our knowledge have to be known, including dose-response relationships applicable to humans, dose-absorption kinetics relating to saturation of defense mechanisms, animal-human extrapolation of toxicological data, the distribution of contaminants and their metabolites at the point of action of target organs, etc.

Introduction

Current knowledge on the adjustment of PEVs to unusual work schedules, meaning schedules other than eight hours per day, five days per week, was recently summarized in several publications particularly relevant to the Québec context[3,4,5,6]. These publications describe the main methods for calculating PEV adjustment factors in the case of substances that require an adjustment.

The basic principle of the adjustment of exposure standards for unusual work schedules consists of *ensuring that workers with unusual work schedules have a degree of protection equivalent to that for workers with a conventional schedule of 8 hours per day, 5 days per week*[7]. In toxicological terms, for many chemical contaminants, an equilibrium is established between the accumulation of a contaminant in the body during the time at work and the elimination of the contaminant during the time away from work (this period is assumed to be exposure-free) until the maximum body burden or accumulation plateau in the body is reached. The time-weighted average exposure value (TWAEV) applicable to workers exposed to these contaminants during unusual work schedules must therefore be modified to ensure that the maximum body burden does not exceed the maximum body burden reached by a worker with a conventional work schedule. As a corollary, no adjustment of the standard is necessary for any means of exposure or any toxic action of a contaminant that is unrelated in any way to the body burden.

With this guiding principle as a basis and using the logic of the Occupational Safety and Health Administration[3] (OSHA) as inspiration, a group of toxicologists met at the IRSST to propose adjustment categories[8] (I, II, III and IV) for each of the substances mentioned in Schedule I of the Regulation respecting occupational health and safety (RROHS) as well as a method for calculating these adjustment factors supported by toxicokinetic modeling[9,10]. This group of experts also defined the conditions and limitations of application of the adjustment procedure.

Using these IRSST recommendations, the members of Technical Committee 3.33.1 for Schedule I of the RROHS of the board of directors of the Commission de la Santé et de la Sécurité du Travail (CSST) established a consensus on the methods of application of PEV adjustment (see Appendix I). The present guide is the tool for facilitating the application of PEV adjustment for unusual work schedules using toxicological considerations as a basis as reviewed by consensus by the members of the Schedule I committee. It provides several definitions and conditions of application, explains the PEV adjustment process and the interpretation of the ***adjusted average exposure value*** **(AAEV)**, and presents some application examples in the appendix.

Adjustment recommendations

Definitions

Repetitive work cycle: calendar period during which the work schedule (work shift) is exactly repeated on a daily and weekly basis.

> For example, the conventional schedule of eight hours per day (Monday to Friday), five days per week is a *repetitive calendar-week work cycle*, as is a schedule of 10 hours per day (Tuesday to Friday). However, a schedule of 12 hours per day for 7 consecutive days, followed by 7 days off, would be a 14-day *repetitive cycle*. If this same schedule consists of alternating weeks of day and night shifts, it would be a *28-day repetitive cycle*.

Average exposure duration in hours per week based on a repetitive work cycle: the arithmetic mean in hours (H_w) of the weekly total (7 days) of the work shifts during the repetitive work cycle.

> For example, the conventional schedule of eight hours per day (Monday to Friday), five days per week, gives an *average exposure duration in hours per week based on a repetitive work cycle* of 40 hours per week; a schedule of 10 hours per day, four days per week (Tuesday to Friday) also represents *an average exposure duration in hours per week based on a repetitive work cycle* of 40 hours per week.

However, a schedule of 12 hours per day for 7 consecutive days, followed by 7 days off, corresponds to *an average exposure duration in hours per week based on a repetitive work cycle* of 42 hours per week.

Multiple exposure: daily exposure to several substances

Nominal schedule: normal work schedule based on the agreement between the employer and worker excluding overtime and occasional replacement work. As a general rule, this schedule should represent at least 80% of the hours actually worked.

Conditions of application

- The PEV adjustment process applies only to nominal schedules of no less than 4 hours or no more than 16 hours.
- In no case can the AAEV be greater than the TWAEV.
- The short-term exposure values (STEV) and ceiling values (CV) are not subject to the adjustment principle.
- In the case of daily exposures to several substances, the equation in part 3 of Schedule I of the RROHS applies by replacing T (TWAEV) by Ta (AAEV).
- The excursion limits for substances that have no STEV apply directly to the AAEV. Similarly, exposures between the STEV and the TWAEV must be taken into consideration as described in the RROHS by replacing the TWAEV by the AAEV.

PEV adjustment procedure

The adjustment procedure is based on the assignment of adjustment categories (Table 1) as proposed by OSHA[3]. Appendix IV gives the adjustment category for each of the substances in the RROHS, namely *no* adjustment (category I), *daily* adjustment (category II), *weekly* adjustment (category III), and *the most conservative* of the daily or weekly adjustments (category IV). The adjustment category for each of the substances in Schedule I of the RROHS is also available on the Internet by means of a downloadable utility at the following address: http://www.irsst.qc.ca/en/_outil_100011.html. (see Appendix III).

Table 1: List of adjustment categories

Ad	Adjustment classification	Type of adjustment
I-a	Substances regulated by a ceiling value	No adjustment
I-b	Irritating or malodorous substances	
I-c	Simple asphyxiants, substances presenting a safety risk or a very low health risk, whose half-life is less than 4 hours. Technological limitations	
II	Substances that produce effects following *short-term* exposure	**Daily** adjustment
III	Substances that produce effects following *long-term* exposure	**Weekly** adjustment
IV	Substances that produce effects following a *short-* or *long-term* exposure	Daily or weekly adjustment **the most conservative of the two**

Calculating the AAEV

In the case of **Category I** substances, the TWAEV does not have to be adjusted, regardless of the type of work schedule. For substances belonging to the other categories, the TWAEV is adjusted by applying one of the following equations:

$F_A = 8/H_d$ for **Category II** substances, which require a daily adjustment,

$F_A = 40/H_w$ for **Category III** substances, which require a weekly adjustment,

F_A = adjustment factor

H_d = exposure duration in hours per shift

H_w = average duration of work shifts per week *based on a repetitive work cycle*.

In the case of **Category IV** substances, the F_A must be calculated for each of the two equations for Categories II and III, and the lowest F_A must be applied.

To obtain the adjustment factor rapidly, Appendix IV of this document supplies the adjustment categories for all of the substances in the RROHS, and Table 2 presents the adjustment factors (F_A) for most of the possible unusual schedules. The only exception to the application of Table 2 involves Category II and IV substances in the case of work schedules in which the work shifts vary in duration from day to day.

To use Table 2, the length of the repetitive work cycle must be determined and the average exposure durations be established based on the adjustment category of the substance considered.

Interpretation of the AAEV

TWAEV

The RROHS defines the TWAEV in the following way:

> "The time-weighted average concentration for an 8-hour workday and a 40-hour workweek of a chemical substance (in the form of gases, dusts, fumes, vapours or mists) present in the air in a worker's respiratory zone."

To verify compliance with the TWAEV, hygienists will evaluate the concentration of a substance present in the workplace by weighting the result or results of the measured concentrations on the basis of a workshift of eight consecutive hours. In this case, *the repetitive work cycle* is one week and the duration of the work shifts is constant from day to day and corresponds to the duration of the hours worked, or eight hours. Regardless of the nature of the pathologies that can be caused by the presence of this substance in the workplace, *verification of compliance with the TWAEV or AAEV is always done a daily basis.*

Table 2: Adjustment factor (F_A) for unusual work schedules based on the duration of work shifts (h/day) and the average duration of work weeks (h/wk)

Category I : No adjustment

Category II

h/day	F_A
8.0	1.00
8.5	0.94
9.0	0.89
9.5	0.84
10.0	0.80
10.5	0.76
11.0	0.73
11.5	0.70
12.0	0.67
12.5	0.64
13.0	0.62
13.5	0.59
14.0	0.57
14.5	0.55
15.0	0.53
15.5	0.52
16.0	0.50

Category III

h/wk	F_A
40.0	1.00
41.0	0.98
42.0	0.95
43.0	0.93
44.0	0.91
45.0	0.89
46.0	0.87
47.0	0.85
48.0	0.83
49.0	0.82
50.0	0.80
51.0	0.78
52.0	0.77
53.0	0.75
54.0	0.74
55.0	0.73
56.0	0.71
57.0	0.70
58.0	0.69
59.0	0.68
60.0	0.67

Category IV

h/wk (F_A)	h/day: 8	9	10	11	12	13	14	15	16
40	1.00	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
41	0.98	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
42	0.95	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
43	0.93	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
44	0.91	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
45	0.89	0.89	0.80	0.73	0.67	0.62	0.57	0.53	0.50
46	0.87	0.87	0.80	0.73	0.67	0.62	0.57	0.53	0.50
47	0.85	0.85	0.80	0.73	0.67	0.62	0.57	0.53	0.50
48	0.83	0.83	0.80	0.73	0.67	0.62	0.57	0.53	0.50
49	0.82	0.82	0.80	0.73	0.67	0.62	0.57	0.53	0.50
50	0.80	0.80	0.80	0.73	0.67	0.62	0.57	0.53	0.50
51	0.78	0.78	0.78	0.73	0.67	0.62	0.57	0.53	0.50
52	0.77	0.77	0.77	0.73	0.67	0.62	0.57	0.53	0.50
53	0.75	0.75	0.75	0.73	0.67	0.62	0.57	0.53	0.50
54	0.74	0.74	0.74	0.73	0.67	0.62	0.57	0.53	0.50
55	0.73	0.73	0.73	0.73	0.67	0.62	0.57	0.53	0.50
56	0.71	0.71	0.71	0.71	0.67	0.62	0.57	0.53	0.50
57	0.70	0.70	0.70	0.70	0.67	0.62	0.57	0.53	0.50
58	0.69	0.69	0.69	0.69	0.67	0.62	0.57	0.53	0.50
59	0.68	0.68	0.68	0.68	0.67	0.62	0.57	0.53	0.50
60	0.67	0.67	0.67	0.67	0.67	0.62	0.57	0.53	0.50

* : the duration of work shifts must be equal from one day to the next.

The most conservative daily adjustment

The most conservative weekly adjustment

AAEV

In the case of AAEV, three situations may arise based on the substance's adjustment category:

Daily adjustment

For a substance whose adjustment must be done on a daily basis (**Category II**), if the work shifts are all of the same length, e.g., 12 hours, the AAEV will be 0.67 x TWAEV, and the results of the concentrations will be weighted over 12 hours. In our experience, the most common situation is a constant duration work shift.

However, if the work shifts are not all of the same length, the simple approach resulting from the consensus of the Schedule I committee (use of the average duration of work shifts) cannot be applied due to toxicological reasoning because it could lead to situations in which the guiding principle would no longer be respected. It then becomes necessary to adjust the TWA for *each work shift duration* and to weight the results according to the duration of the corresponding work shift.

Weekly adjustment

Category III substances, which require a weekly adjustment, consist of all the substances whose effects appear after long-term exposure. Adjustment on the basis of the *average exposure duration in hours per week based on a repetitive work cycle* is logical toxicologically. Therefore, for example, a work schedule of 12 hours per day for 7 consecutive days followed by 7 days off gives an average of 42 hours per week and an adjustment factor of 40/42 or 0.95.

The adjustment factor is used only to calculate the AAEV. Weighting of the concentration measurement(s) to verify compliance with the standard must be calculated over the duration of the work shift. In the example, weighting will be over 12 hours. If work shifts are of unequal length from one shift to the next, the weighting must be done over the duration of each of the work shifts.

Daily or weekly adjustment (*the most conservative of the two*)

For **Category IV** substances, the most conservative of the daily or weekly adjustments must be calculated. The same calculation criteria for the AAEV and the weighting of the results apply to this category.

Use of the AAEV

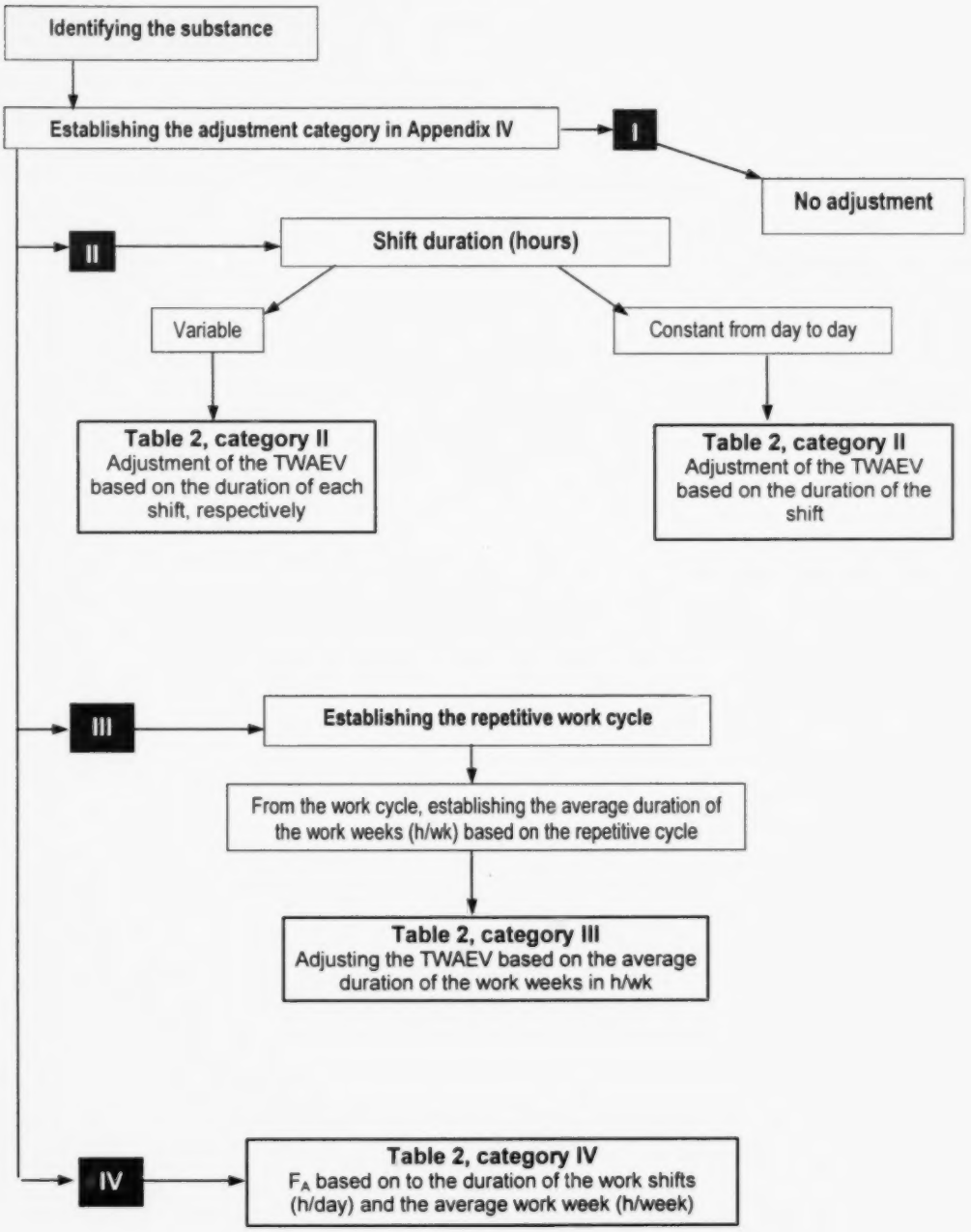
In the case of a daily exposure to a given substance for a worker working at several work locations and who has an unusual work schedule, calculation of the *average daily exposure* is done over the entire work shift and is then compared to the AAEV, as described in Part 2 of Schedule I of the RROHS[1].

In the case of a situation in which there is daily exposure to several substances and an unusual work schedule, the *mixed exposure index* (Rm) is calculated by using the AAEV instead of the TWAEV in the denominator, as described in Part 3 of Schedule I of the RROHS[1].

Conclusion

The process of adjusting a TWAEV into an AAEV is summarized in Figure 1. An AAEV cannot be greater than the TWAEV. STEVs and CVs are never adjusted. All the other definitions and provisions of the RROHS apply to the AAEV by replacing the TWAEV by the AAEV in the text.

Figure 1: TWAEV adjustment process


Identifying the substance
Establishing the adjustment category in Appendix IV
I
No adjustment
II
Shift duration (hours)
Variable
Constant from day to day
Table 2, category II
Adjustment of the TWAEV based on the duration of each shift, respectively
Table 2, category II
Adjustment of the TWAEV based on the duration of the shift
III
Establishing the repetitive work cycle
From the work cycle, establishing the average duration of the work weeks (h/wk) based on the repetitive cycle
Table 2, category III
Adjusting the TWAEV based on the average duration of the work weeks in h/wk
IV
Table 2, category IV
F_A based on to the duration of the work shifts (h/day) and the average work week (h/week)

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Appendix I: Consensus of the Schedule 1 Committee on the adjustment of PEVs for unusual work schedules

Conditions of application

- The adjustment must not allow exposure above the time-weighted average exposure value (TWAEV).
- Short-term exposure values (STEV) are not subject to adjustment.

Assigning adjustment categories

- Add to Category **I**, without adjustment, "Substances whose half-life is less than 4 hours".
- Include acetone, aniline, chlorine, hexane (other isomers) and hydrogen sulfide in Category **I**, without adjustment.

Appendix II: Examples of PEV adjustment

The PEV adjustment process is presented in the form of scenarios taken from real workplace situations. Appendix IV indicates the adjustment categories for all the substances in Schedule I of the RROHS.

Scenario 1

Scenario 1 raises the question about exposure to hydrogen cyanide (hydrocyanic acid) by workers with schedules different from eight hours per day, five days per week.

The adjustment category for this substance as found in Appendix IV of this document is **I-a**. Figure 1 informs us that for all Category **I** substances, there is no adjustment regardless of the work schedule.

Scenario 2

A laboratory technician regularly uses acetonitrile as a solvent. He works 12 hours per day, 4 days per week, with alternating weeks from Monday to Thursday and from Tuesday to Friday. What is the AAEV that applies in his case?

Appendix IV indicates adjustment category **II** for acetonitrile, or on a daily basis. Figure 1 indicates that for all category II substances, one first has to specify whether the work shifts in his nominal schedule are always the same length from day to day. In this case, the duration of the work shifts is constant at 12 hours, so we consult Table 2. Under the "Category II" heading, at 12.0 h/day, the adjustment factor is 0.67. The AAEV is therefore **45 mg/m³** (67 mg/m³ x 0.67).

The sampling strategy[11] must anticipate a 12-hour weighting of the representative results for the entire shift.

Scenario 3

In a plant recovering lead from automobile batteries and other sources, workers have schedules with 12-hour shifts for consecutive 3-day and 4-day weeks. What would be the AAEV for lead that would apply to these workers?

Appendix IV indicates adjustment category III for "Lead and its inorganic compounds, dusts and fumes (expressed as Pb)", or on a weekly basis. Figure 1 indicates that for all category **III** substances, the **repetitive work cycle** must first be specified, or two weeks (14 days), and **the average exposure duration in hours per week based on a repetitive work cycle**, or 42 hours ((36+48)/2). This allows us to consult Table 2; under the "Category III" heading, at 42.0 h/week, the adjustment factor is 0.95. Therefore the AAEV becomes **0.14 mg/m³** (0.15 mg/m³ x 0.95).

The sampling strategy must anticipate a 12-hour weighting of the representative results [11] for the entire shift.

Scenario 4

A fiberglass pleasure boat manufacturing plant has a work schedule consisting of three working days followed by three days off. All the work shifts are 12 hours. For workers using styrene to manufacture the polymeric coating, what would the AAEV be?

Appendix IV indicates adjustment category **IV** for styrene, or that the most conservative daily or weekly value must be used. Figure 1 indicates that for all category **IV** substances, categories II and III must be calculated and the most conservative result of the two must be applied.

Therefore, for category II, since all the work shifts are of the same length, or 12 hours, Table 2, under the "Category II" heading at 12 h/day, the adjustment factor is 0.67. The AAEV would therefore be **142 mg/m³** (213 mg/m³ x 0.67).

For category III, the **repetitive work cycle** must first be specified, which is 42 days, as summarized in the following table:

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	**W**	**W**	**W**	A	A	A	**W**
2	**W**	**W**	A	A	A	**W**	**W**
3	**W**	A	A	A	**W**	**W**	**W**
4	A	A	A	**W**	**W**	**W**	A
5	A	A	**W**	**W**	**W**	A	A
6	A	**W**	**W**	**W**	A	A	A

W: work, A: Absence

This cycle includes three weeks of 3 shifts (36 hours) and three weeks of 4 shifts (48 hours). The **average exposure duration in hours per week based on a repetitive work cycle** is 42 hours ((36*3)+(48*3))/6). We then consult Table 2; under the "Category III" heading, at 42.0 h/week, the adjustment factor is 0.95. Therefore the AAEV would be **203 mg/m³** (213 mg/m³ x 0.95).

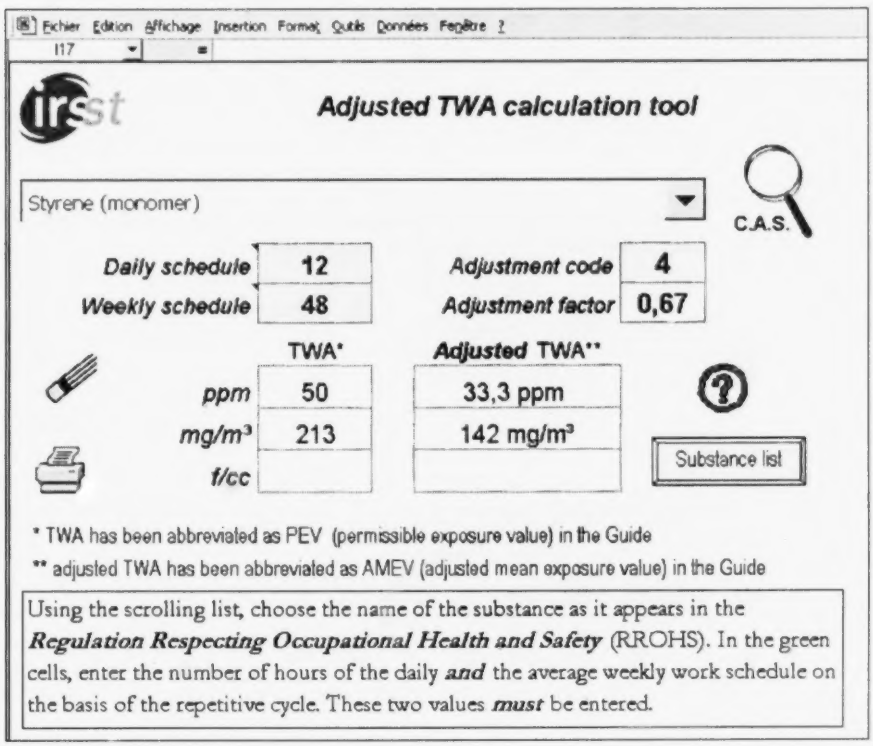
The AAEV of **142 mg/m³**, being the most conservative, is therefore applicable to these workers' exposure. Table 2 under the "Category IV" heading arrives at the same conclusion. In fact, the intersection point of the 42-hour row and the 12-hour column gives an adjustment factor (F_A) of 0.67.

The sampling strategy must anticipate a 12-hour weighting of the representative results[11] for the entire shift.

Appendix III: Computer utility for TWA adjustment

The following figure shows the utility available on the IRSST's Web site. It is an EXCEL file operating with version 97 (or a later version) and that can be downloaded from the following address: http://www.irsst.qc.ca/en/_outil_100011.html.

The data for scenario 4 of Appendix II were entered as an example.


Fichier Edition Affichage Insertion Format Outils Données Fenêtre ?
I17
irsst
Adjusted TWA calculation tool
Styrene (monomer)
C.A.S.
Daily schedule 12
Weekly schedule 48
Adjustment code 4
Adjustment factor 0,67
TWA*
Adjusted TWA**
ppm 50 33,3 ppm
mg/m³ 213 142 mg/m³
f/cc
Substance list
* TWA has been abbreviated as PEV (permissible exposure value) in the Guide
** adjusted TWA has been abbreviated as AMEV (adjusted mean exposure value) in the Guide
Using the scrolling list, choose the name of the substance as it appears in the Regulation Respecting Occupational Health and Safety (RROHS). In the green cells, enter the number of hours of the daily and the average weekly work schedule on the basis of the repetitive cycle. These two values must be entered.

Appendix IV: Adjustment category for RROHS substances

Acetaldehyde	I
Acetic acid	I
Acetic anhydride	I
Acetone	I
Acetone cyanohydrin	I
Acetonitrile	II
Acetophenone	I
Acetylene	I
Acetylsalicylic acid (Aspirin)	II
Acrolein	I
Acrylamide	III
Acrylic acid	I
Acrylonitrile	III
Adipic acid	III
Adiponitrile	IV
Aldrin	IV
Allyl alcohol	I
Allyl glycidyl ether (AGE)	I
Allyl propyl disulfide	I
Aluminum [7429-90-5], (as Al), Alkyls (NOC)	I
Aluminum (as Al), Metal	I
Aluminum [7429-90-5], (as Al), Pyrotechnical powders	I
Aluminum [7429-90-5], (as Al), Soluble salts	I
Aluminum [7429-90-5], (as Al), Welding fumes	I
Aluminum oxide (as Al)	I
4-Aminodiphenyl	III
2-Aminoethanol	III
2-Aminopyridine	II
Amitrole	III
Ammonia	I
Ammonium chloride fume	I
Ammonium perfluorooctanoate	III
Ammonium sulfamate	I
n-Amyl acetate	I
sec-Amyl acetate	I
Aniline	I
o-Anisidine	II
p-Anisidine	II
Antimony [7440-36-0], metal and compounds (as Sb)	III
Antimony trioxide (as Sb)	III
Antimony trioxide, production (as Sb)	III
ANTU (alpha-Naphthylthiourea)	II
Argon	I
Arsenic, elemental [7440-38-2], and inorganic compounds (except Arsine) (as As)	III
Arsenic trioxide, production	III
Arsine	IV
Asbestos, Actinolite	III
Asbestos, Amosite	III
Asbestos, Anthophyllite	III
Asbestos, Chrysotile	III
Asbestos, Crocidolite	III
Asbestos, Tremolite	III
Asphalt (petroleum) fumes	III
Atrazine	II
Azinphos-methyl	IV
Barium, soluble compounds (as Ba)	II
Barium sulfate, total dust	III
Barium sulfate, respirable dust	III
Benomyl	I
Benz(a)anthracene	III
Benzene	III
Benzidine (production)	III
Benzo(a)pyrene	III
Benzo(b)fluoranthene	III
p-Benzoquinone	I
Benzoyl peroxide	I
Benzyl chloride	IV
Beryllium [7440-41-7], metal and compounds (as Be)	III
Biphenyl	I
Bismuth telluride (as Bi2Te3), Se-doped	III
Bismuth telluride (as Bi2Te3), Undoped	I
Boron oxide	I
Boron tribromide	I
Boron trifluoride	I
Bromacil	III
Bromine	I
Bromine pentafluoride	I
Bromoform	IV
Bromotrifluoromethane	I
1,3-Butadiene	III
Butane	I
2-Butoxyethanol	III
n-Butyl acetate	I
sec-Butyl acetate	I
tert-Butyl acetate	I
n-Butyl acrylate	I
n-Butyl alcohol	I
sec-Butyl alcohol	II
tert-Butyl alcohol	II
tert-Butyl chromate (as CrO3)	I
n-Butyl glycidyl ether (BGE)	III
n-Butyl lactate	I
Butyl mercaptan	I
n-Butylamine	I
o-sec-Butylphenol	I
p-tert-Butyltoluene	III
Cadmium elemental and compouds (as Cd)	III
Calcium carbonate	I
Calcium cyanamide	I
Calcium hydroxide	I
Calcium oxide	I
Calcium silicate (synthetic)	I
Calcium sulfate, total dust	I
Calcium sulfate, respirable dust	I
Camphor (synthetic)	I
Caprolactam, Dust	I
Caprolactam, Vapour	I
Captafol	III
Captan	III
Carbaryl	IV
Carbofuran	IV
Carbon black	III
Carbon dioxide	I
Carbon disulfide	IV
Carbon monoxide	IV
Carbon tetrabromide	IV
Carbon tetrachloride	IV
Carbonyl fluoride	IV
Catechol	IV
Cellulose (paper fibres)	I
Cesium hydroxide	I
Chlordane	IV
Chlorinated camphene	IV
Chlorinated diphenyl oxide	III
Chlorine	I
Chlorine dioxide	II
Chlorine trifluoride	I
Chloroacetaldehyde	I
Chloroacetone	I
alpha-Chloroacetophenone	I
Chloroacetyl chloride	I
Chlorobenzene	IV

o-Chlorobenzylidene malononitrile	I
Chlorobromomethane	III
Chlorodifluoromethane	I
Chlorodiphenyl (42% chlorine)	III
Chlorodiphenyl (54% chlorine)	III
Chloroform	IV
Chloromethyl methyl ether	III
bis (Chloromethyl) ether	III
1-Chloro-1-nitropropane	II
Chloropentafluoroethane	I
Chloropicrin	II
ß-Chloroprene	IV
3-Chloropropene (allyl chloride)	III
2-chloropropionic acid	III
o-Chlorostyrene	IV
o-Chlorotoluene	I
Chlorpyrifos	IV
Chromite ore processing (chromate) (as Cr)	III
Chromium (metal)	III
Chromium (II) compounds (as Cr)	III
Chromium (III) compounds (as Cr)	III
Chromium (VI) compounds, Certain water insoluble (as Cr)	III
Chromium (VI) compounds, Water soluble (as Cr)	III
Chromyl chloride	III
Chrysene	III
Clopidol	I
Coal dust (less than 5% crystalline silica)	III
Coal dust (more than 5% crystalline silica)	III
Coal tar pitch volatiles, as benzene solubles	III
Cobalt [7440-48-4], metal dust and fume (as Co)	III
Cobalt hydrocarbonyl (as Co)	II
Cobalt tetracarbonyl (as Co)	II
Copper [7440-50-8], Fume (as Cu)	II
Copper [7440-50-8], Dust and mists (as Cu)	I
Corundum	I
Cotton dust, cotton waste processing operation of waste recycling and garnetting	III
Cotton dust, in yarn manufacturing and cotton washing operations	III
Cotton dust, in textile mill waste house operations or in yarn manufacturing to dust from "lower-grade washed cotton"	III
Cotton dust, in textile slashing and weaving operations	III
Cresol (all isomers)	I
Crotonaldehyde	I
Crufomate	IV

Cumene	II
Cyanamide	I
Cyanides (as Cn)	I
Cyanogen	I
Cyanogen chloride	I
Cyclohexane	I
Cyclohexanol	IV
Cyclohexanone	III
Cyclohexene	I
Cyclohexylamine	I
Cyclonite	III
Cyclopentadiene	I
Cyclopentane	IV
Cyhexatin	I
2,4-D	III
DDT (Dichlorodiphenyltrichloroethane)	IV
Decaborane	IV
Demeton®	IV
Di-sec-octyl phthalate	III
2,6-Di-tert-butyl-p-cresol	I
Diacetone alcohol	I
1,6-Diaminohexane	I
Diazinon®	IV
Diazomethane	IV
Diborane	IV
1,2-Dibromoethane	III
Dibutyl phenyl phosphate	IV
Dibutyl phosphate	I
Dibutyl phthalate	I
2-N-Dibutylaminoethanol	III
1,3-Dichloro -5,5-dimethyl hydantoin	I
Dichloroacetylene	I
o-Dichlorobenzene	I
p-Dichlorobenzene	III
3,3'-Dichlorobenzidine	III
1,4-Dichloro-2-butene	III
Dichlorodifluoromethane	I
1,1-Dichloroethane	IV
1,2-Dichloroethane	III
Dichloroethyl ether	II
1,1-Dichloroethylene	III
1,2-Dichloroethylene	IV
Dichlorofluoromethane	IV
1,1-Dichloro-1-nitroethane	II
1,2-Dichloropropane	IV
Dichloropropene (cis and trans)	IV
2,2-Dichloropropionic acid	I

1,2 Dichloro-1,1,2,2-tetrafluoroethane	I
Dichlorvos	IV
Dicrotophos	IV
Dicyclopentadiene	III
Dicyclopentadienyl iron	I
Dieldrin	IV
Diethanolamine	I
Diethyl ether	I
Diethyl ketone	II
Diethyl phthalate	III
Diethylamine	I
2-Diethylaminoethanol	I
Diethylene triamine	III
Difluorodibromomethane	IV
Diglycidyl ether (DGE)	III
Diisobutyl ketone	I
Diisopropyl ether	I
Diisopropylamine	I
Dimethyl carbamoyl chloride	III
Dimethyl sulfate	III
N,N-Dimethylacetamide	IV
Dimethylamine	I
N,N-Dimethylaniline	IV
N,N-Dimethylformamide	III
1,1-Dimethylhydrazine	III
Dimethylphthalate	I
Dinitolmide	III
Dinitro-ortho-cresol	III
Dinitrobenzene (all isomers)	IV
Dinitrotoluene	IV
Dioxane	III
Dioxathion	III
Diphenylamine	IV
Dipropylene glycol monomethyl ether	II
Diquat, total dust	III
Diquat, respirable dust	III
Disulfiram	II
Disulfoton	IV
Diuron	I
Divinyl benzene	I
Emery	I
Endosulfan	IV
Endrin	II
Enflurane	II
Epichlorohydrin	IV
EPN	IV
Ethane	I

Ethion	IV
2-Ethoxyethanol (EGEE)	IV
2-Ethoxyethyl acetate (EGEEA)	IV
Ethyl acetate	I
Ethyl acrylate	I
Ethyl alcohol	I
Ethyl amyl ketone	I
Ethyl benzene	III
Ethyl bromide	IV
Ethyl butyl ketone	II
Ethyl chloride	IV
Ethyl formate	I
Ethyl mercaptan	I
Ethyl silicate	III
Ethylamine	I
Ethylene	I
Ethylene chlorohydrin	I
Ethylene glycol (vapour and mist)	I
Ethylene glycol dinitrate	I
Ethylene imine	IV
Ethylene oxide	III
Ethylenediamine	III
Ethylidene norbornene	I
N-Ethylmorpholine	II
Fenamiphos	IV
Fensulfothion	IV
Fenthion	IV
Ferbam	I
Ferrovanadium (dust)	I
Fibres, Artificial Vitreous Mineral Fibres, Fibrous glass, continuous filament	I
Fibres, Artificial Vitreous Mineral Fibres, Fibrous glass, microfibres	III
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Glass wool	III
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Rock wool	III
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Slag wool	III
Fibres, Artificial Vitreous Mineral Fibres, Refractory fibres (ceramic or others)	III
Fibres, Natural Mineral Fibres, Attapulgite	III
Fibres, Natural Mineral Fibres, Erionite	I
Fibres-Natural Mineral Fibres, Wollastonite	I
Fibres-Natural Mineral Fibres, Wollastonite	I
Fibres, Organic Synthetic Fibres, Carbon and graphite fibres	III
Fibres, Organic Synthetic Fibres, Carbon and graphite fibres	III
Fibres, Organic Synthetic Fibres, Para-aramide fibres (Kevlar®, Twaron®)	III
Fibres, Organic Synthetic Fibres, Polyolefin fibres	I
Fluorides (as F)	III
Fluorine	I
Fonofos	IV
Formaldehyde	I
Formamide	III
Formic acid	I
Furfural	I
Furfuryl alcohol	I
Gasoline	II
Germanium tetrahydride	II
Glutaraldehyde	I
Glycerin (mist)	I
Glycidol	I
Grain dust (oat, wheat, barley)	IV
Graphite (natural)	III
Graphite (synthetic, except fibres)	III
Gypsum, total dust	I
Gypsum, respirable dust	I
Hafnium	III
Halothane	IV
Helium	I
Heptachlor	IV
Heptachlore epoxide	III
n-Heptane	II
Hexachlorobenzene	III
Hexachlorobutadiene	III
Hexachlorocyclopentadiene	IV
Hexachloroethane	III
Hexachloronaphthalene	III
Hexafluoroacetone	IV
Hexamethyl phosphoramide	III
Hexamethylene diisocyanate	III
n-Hexane	IV
Hexane (other isomers)	I
sec-Hexyl acetate	I
Hexylene glycol	I
Hydrazine	III
Hydrogen	I
Hydrogen bromide	I
Hydrogen chloride	I
Hydrogen cyanide	I
Hydrogen fluoride (as F)	I
Hydrogen peroxide	I
Hydrogen selenide (as Se)	IV
Hydrogen sulfide	I
Hydrogenated terphenyls	III
Hydroquinone	IV
2-Hydroxypropyl acrylate	I
Indene	I
Indium [7440-74-6] and compounds (as In)	IV
Iodine	I
Iodoform	II
Iron pentacarbonyl (as Fe)	II
Iron salts, soluble (as Fe)	I
Iron trioxide, dust and fume (as Fe)	III
Isoamyl acetate	I
Isoamyl alcohol	II
Isobutyl acetate	I
Isobutyl alcohol	I
Isocyanate oligomers	III
Isooctyl alcohol	II
Isophorone	I
Isophorone diisocyanate	III
Isopropoxyethanol	III
Isopropyl acetate	I
Isopropyl alcohol	II
Isopropyl glycidyl ether (IGE)	III
Isopropylamine	I
N-Isopropylaniline	II
Kaolin	III
Ketene	II
L.P.G. (Liquified petroleum gas)	I
Lead and inorganic compounds, dusts and fumes (as Pb)	III
Lead arsenate (as Pb3(AsO4)2)	IV
Lead chromate (as Cr)	III
Lead tetraethyl (as Pb)	III
Lead tetramethyl (as Pb)	III
Lindane	IV
Lithium hydride	I
Magnesite	I
Magnesium oxide fume (as Mg)	II
Malathion	IV
Maleic anhydride	IV
Manganese [7439-96-5] (as Mn), Dust and compounds	III
Manganese (as Mn), Fume	IV
Manganese cyclopentadienyl tricarbonyl (as Mn)	IV
Manganese methyl cyclopentadienyl tricarbonyl (as Mn)	IV
Manganese tetroxide	III
Mercury [7439-97-6], Alkyl compounds (as Hg)	IV
Mercury [7439-97-6] all forms except alkyl compounds (as Hg)	III

Aryl and inorganic compounds	
Mercury [7439-97-6], all forms except alkyl compounds (as Hg), vapour	IV
Mesityl oxide	I
Methacrylic acid	I
Methane	I
Methomyl	IV
Methoxychlor	IV
2-Methoxyethanol (EGME)	IV
2-Methoxyethyl acetate (EGMEA)	IV
4-Methoxyphenol	I
Methyl acetate	II
Methyl acetylene	I
Methyl acetylene-propadiene mixture (MAPP)	I
Methyl acrylate	I
Methyl alcohol	IV
Methyl amyl alcohol	I
Methyl n-amyl ketone	I
Methyl bromide	IV
Methyl tert-butyl ether	IV
Methyl n-butyl ketone	III
Methyl chloride	IV
Methyl chloroform	II
Methyl 2-cyanoacrylate	III
Methyl demeton	IV
Methyl ethyl ketone (MEK)	I
Methyl ethyl ketone peroxide	I
Methyl formate	I
Methyl hydrazine	I
Methyl iodide	IV
Methyl isoamyl ketone	I
Methyl isobutyl ketone	I
Methyl isocyanate	III
Methyl isopropyl ketone	I
Methyl mercaptan	I
Methyl methacrylate (monomer)	I
Methyl parathion	IV
Methyl propyl ketone	II
Methyl silicate	II
alpha-Methyl styrene	II
Methylacrylonitrile	IV
Methylal	I
Methylamine	I
N-Methylaniline	IV
Methylcyclohexane	I
Methylcyclohexanol	III
o-Methylcyclohexanone	I
Methylene chloride	IV

4,4'-Methylene bis (2-chloroaniline)	IV
Methylene bis (4-cyclohexylisocyanate)	III
4,4'-Methylene dianiline	III
Methylene bis (4-phenyl isocyanate) (MDI)	III
Metribuzin	II
Mica	III
Mineral oil (mist)	III
Molybdenum [7439-98-7] (as Mo), Insoluble compounds	I
Molybdenum [7439-98-7] (as Mo), Soluble compounds	I
Monocrotophos	IV
Morpholine	I
Naled	IV
Naphthalene	I
ß-Naphthylamine	III
Neon	I
Nickel, Metal	III
Nickel [7440-02-0], Insoluble compounds (as Ni)	III
Nickel [7440-02-0], Soluble compounds (as Ni)	III
Nickel carbonyl (as Ni)	II
Nickel sulfide roasting, fume and dust (as Ni)	III
Nicotine	II
Nitrapyrin	I
Nitric acid	II
p-Nitroaniline	IV
Nitrobenzene	IV
p-Nitrochlorobenzene	IV
4-Nitrodiphenyl	III
Nitroethane	I
Nitrogen	I
Nitrogen dioxide	IV
Nitrogen monoxide	II
Nitrogen trifluoride	II
Nitroglycerin (NG)	I
Nitromethane	IV
1-Nitropropane	III
2-Nitropropane	III
N-Nitrosodimethylamine	III
Nitrotoluene (all isomers)	II
Nitrous oxide	III
Nonane	II
Octachloronaphthalene	III
Octane	II
Osmium tetroxide (as Os)	I
Oxalic acid	I
Oxygen difluoride	I
Ozone	I

Paraffin wax, fume	I
Paraquat, respirable particulates	III
Parathion	IV
Particulates Not Otherwise Classified (PNOC)	I
Pentaborane	II
Pentachloronaphthalene	III
Pentachloronitrobenzene	III
Pentachlorophenol	III
Pentaerythritol	I
n-Pentane	II
Perchloroethylene	IV
Perchloromethyl mercaptan	II
Perchloryl fluoride	IV
Perfluoroisobutylene	I
Perlite, total dust	I
Perlite, respirable dust	I
Phenol	IV
Phenothiazine	III
Phenyl ether, vapour	I
Phenyl glycidyl ether (PGE)	III
Phenyl mercaptan	I
meta-Phenylenediamine	III
ortho-Phenylenediamine	III
p-Phenylenediamine	III
Phenylhydrazine	III
n-Phenyl-ß-naphthylamine	III
Phenylphosphine	I
Phorate	IV
Phosdrin	IV
Phosgene	II
Phosphine	II
Phosphoric acid	I
Phosphorus (yellow)	I
Phosphorus oxychloride	I
Phosphorus pentachloride	I
Phosphorus pentasulfide	I
Phosphorus trichloride	I
Phthalic anhydride	III
m-Phthalodinitrile	I
Picloram	I
Picric acid	III
Pindone	III
Piperazine dihydrochloride	III
Plaster of Paris, total dust	I
Plaster of Paris, respirable dust	I
Platinum , Metal	III
Platinum [7440-06-4], Soluble salts (as Pt)	III

Polytetrafluoroethylene decomposition products	II
Portland cement, total dust	I
Portland cement, respirable dust	I
Potassium hydroxide	I
Propane	I
Propane sultone	III
Propargyl alcohol	I
ß-Propiolactone	III
Propionic acid	I
Propoxur (baygon)	IV
n-Propyl acetate	I
n-Propyl alcohol	I
n-Propyl nitrate	II
Propylene	I
Propylene glycol dinitrate	IV
Propylene glycol monomethyl ether	IV
Propylene imine	III
Propylene oxide	III
Pyrethrum	III
Pyridine	III
Resorcinol	II
Rhodium [7440-16-6], Metal and insoluble compounds (as Rh)	III
Rhodium [7440-16-6], Soluble compounds (as Rh)	III
Ronnel	IV
Rosin core solder pyrolysis products (as Formaldehyde)	III
Rotenone	IV
Rouge	I
Rubber solvent (Naphtha)	II
Selenium and compounds (as Se)	IV
Selenium hexafluoride (as Se)	IV
Sesone	III
Silica, Amorphous, Diatomaceous earth (uncalcined)	I
Silica - Amorphous, fumes	III
Silica, Amorphous, fused	III
Silica, Amorphous, gel	I
Silica, Amorphous, precipitated	I
Silica, Crystalline, Cristobalite	III
Silica, Crystalline, Quartz	III
Silica, Crystalline, Tridymite	III
Silica, Crystalline, Tripoli	III
Silicon	I
Silicon carbide (non fibrous)	I
Silicon tetrahydride	II
Silver, Metal	III
Silver [7440-22-4], Soluble compounds (as Ag)	III
Soapstone, total dust	III
Soapstone, respirable dust	III
Sodium azide	I
Sodium bisulfite	I
Sodium fluoroacetate	II
Sodium hydroxide	I
Sodium metabisulfite	I
Borates, tetra, sodium salt , Anhydrous	I
Borates, tetra, sodium salt , Decahydrate	I
Borates, tetra, sodium salt , Pentahydrate	I
Starch	III
Stibine (as Sb)	IV
Stoddard solvent	IV
Strychnine	II
Styrene (monomer)	IV
Subtilisins (Proteolytic enzymes as 100 % pure crystalline enzyme)	I
Succinaldehyde	I
Sucrose	I
Sulfometuron methyl	III
Sulfotep	IV
Sulfur dioxide	I
Sulfur hexafluoride	I
Sulfur monochloride	I
Sulfur pentafluoride	I
Sulfur tetrafluoride	I
Sulfuric acid	I
Sulfuryl fluoride	III
Sulprofos	IV
2,4,5-T	I
Talc, fibrous	III
Talc, non fibrous	III
Tantalum [7440-25-7], metal and oxide dusts (as Ta)	I
Tellurium and compounds (as Te)	IV
Tellurium hexafluoride (as Te)	II
Temephos	IV
TEPP	IV
Terephthalic acid	I
Terphenyls	I
1,1,2,2-Tetrabromoethane	IV
1,1,1,2-Tetrachloro-2,2-difluoroethane	IV
1,1,2,2-Tetrachloro-1, 2-difluoroethane	IV
1,1,2,2-Tetrachloroethane	IV
Tetrachloronaphthalene	III
Tetrahydrofuran	I
Tetramethyl succinonitrile	II
Tetranitromethane	IV
Tetrasodium pyrophosphate	I
Tetryl	III
Thallium, elemental [7440-28-0], and soluble compounds (as Tl)	III
4,4'-Thiobis (6-tert-butyl-m-cresol)	I
Thioglycolic acid	I
Thionyl chloride	I
Thiram®	III
Tin, Metal	III
Tin [7440-31-5], Organic compounds (as Sn)	III
Tin [7440-31-5], Oxide and inorganic compounds, except SnH4 (as Sn)	III
Titanium dioxide	I
o-Tolidine	III
Toluene	IV
Toluene diisocyanate (TDI) (isomers mixture)	III
o-Toluidine	IV
m-Toluidine	II
p-Toluidine	IV
Tributyl phosphate	I
Trichloroacetic acid	I
1,2,4-Trichlorobenzene	I
1,1,2-Trichloroethane	IV
Trichloroethylene	II
Trichlorofluoromethane	I
Trichloronaphthalene	III
1,2,3-Trichloropropane	III
1,1,2-Trichloro-1,2,2-trifluoroethane	II
Tri-o-cresyl phosphate	III
Triethanolamine	III
Triethylamine	IV
Trimellitic anhydride	III
Trimethyl benzene	III
Trimethyl phosphite	I
Trimethylamine	I
2,4,6-Trinitrotoluene (TNT)	III
Triphenyl amine	I
Triphenyl phosphate	IV
Tungsten [7440-33-7] (as W) , Insoluble compounds	I
Tungsten [7440-33-7] (as W) , Soluble compounds	II
Turpentine	I
Uranium [7440-61-1] (natural) , Insoluble compounds (as U)	III
Uranium (natural) [7440-61-1], Soluble compounds (as U)	III
n-Valeraldehyde	I
Vanadium pentoxide, fume and respirable dust (as V2O5)	I
Vegetable oil mists (except castor, cashew and other similar irritant oils)	I

Vinyl acetate	I
Vinyl bromide	III
Vinyl chloride (monomer)	III
Vinyl cyclohexene dioxide	III
Vinyl toluene	I
VM&P Naphtha	I
Warfarin	IV
Welding fumes (not otherwise classified)	II
Wood dust (western red cedar)	III
Wood dust hard and soft, except red cedar	III
Xylene (o-,m-,p- isomers)	II
m-Xylene-alpha, alpha'-diamine	I
Xylidine (mixed isomers)	III
Yttrium [7440-65-5], metal and compounds (as Y)	III
Zinc chloride, fume	II
Zinc chromates (as Cr)	III
Zinc stearate	I
Zinc, oxide, Dust	I
Zinc, oxide, Fume	II
Zirconium [7440-67-7] and compounds (as Zr)	I